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Some Ecological Studies of the Vegetation at the Cheyenne Bottoms Waterfowl Refuge

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SOME ECOLOGICAL STUDIES OF THE VEGETATION AT

THE CHEYENNE BOTTOMS WATERFOWL REFUGE

being

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by

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INTRODUCTION

A survey of the Cheyenne Bottoms Waterfowl Refuge was made in April, 1960. Upon completion of the survey, plans were made to study the vegetation in relation to various environmental factors.

The environmental factors considered were moisture, temperature, texture, structure and pH of the soils and water level variations in the pools.

Many problems have arisen since the establishment of Cheyenne Bottoms as a waterfowl refuge. For example, damage due to water waves on the existing dikes is a great problem and needs immediate attention. Pool one was originally intended to have 5 to 6 feet of water in its boundaries but because of the severe wind-water-wave erosion of the water level is often held below this mark. Therefore, a uniform water cover in the other four pools surrounding pool one is difficult and occasionally impossible to maintain.

The primary objective of the Cheyenne Bottoms Refuge is to utilize its potential as a feeding and resting area for migratory waterfowl. Other objectives of secondary importances are to encourage waterfowl production, wintering of waterfowl and desirable non-waterfowl species, and to provide a waterfowl hunting area for the public.

An important phase of the management of the Cheyenne Bottoms Refuge area is water manipulation. Proper water management encourages the production of favorable quantities and qualities of food, cover, and the attainment of optimum water levels required by waterfowl throughout the year.

Many studies have been related to the specific environmental characteristics influencing aquatic vegetation. Penfound and Hathaway (1938) found salinity as a factor determining plant distribution in Louisiana marshes. Wilson (1935), working in Wisconsin, found plant succession was dependent upon the type of soil accumulating in the lakes. Moyle (1945) reported that even free-floating plants are dependent upon the fertility of the submerged soil for successful growth. Some studies have placed emphasis on the productivity and taxonomy of aquatic enviroments. A study of the dynamics of a Minnesota pond was conducted by Dineen (1953). Plant communities of Oklahoma lakes were studied by Penfound (1953). Jewell (1927) studied the salt marsh plants found in Stafford County, Kansas. Tiemeier (1951) mapped the vegetation and studied its changes at Kanopolis Reservoir. An extensive five year study of salt cedar (Tamarix gallica) at Cedar Bluff Reservoir was made by the Division of Biological Sciences, Fort Hays Kansas State College (1956 to 1960, inclusive).

In nature, there are several types of habitats related to water content, but each plant species is capable of growing only in those habitats where it finds a suitable water relation. Cheyenne Bottoms is characterized by three primary types of vegetation as related to available soil moisture. One type flourishes in dry elevated sites while another is found only in low habitats. The third is vegetation that grows on saline-alkali soils. These three types of vegetation are termed xerophytes, hydrophytes, and halophytes, respectively.

Hydrophytic plants are found in all pools, while halophytic and xerophytic plants are found on the elevates and fringe portions of the pools. Consequently, the dikes separating the pools are characterized on the upper portions by both xerophytes and halophytes while lower portions near the waters edge support hydrophytes.

The purpose of this study was to collect data on the vegetation and the environmental factors influencing the growth in the Cheyenne Bottoms Waterfowl Refuge Area.

METHODS

Study began in April, 1960. Cover, composition, and vegetational variations due to water level fluctuations in the pools were ascertained by use of the point-quadrat, line-transect, belt-transect, square-foot quadrat, and clip-quadrat methods. Cover and composition along the dikes were also measured by the point-quadrat method.

The point quadrat method is a technique developed by Levy and Madden (1933) in New Zealand (Drew, 1944) and involves the use of a steel frame one meter in length with ten metal pins inserted vertically at one-decimeter intervals (Coupland, 1950). The frame is placed in position at a spot picked at random. Each time a pin strikes the base of a plant a hit for the species is recorded. Basal area, percentage composition by species, frequency, and dominance may be obtained from this data. The point-quadrat method was used in determining the cover, percentage composition by species, frequency, and species dominance of the vegetation in pools two, three, four and five. This method was also employed on the dikes separating the pools.

The transect is essentially an elongated quadrat, which in its simplest form may be a line through communities or a series of communities.

The line transect was used as a guide for vegetation analysis at various intervals along the line. The point quadrat, square-foot quadrat, and clip quadrat were all used in conjunction with the line transect to measure composition and production. The line-transect method of vegetative analysis is valuable when a transition in soil, water and topographical factors make it desirable to show how vegetation will vary with the changes in environment (Weaver and Clements, 1938; Gates, 1949; and Oosting, 1956). The line transects were used in pool four. The first transect was established May 20, 1960, with the aid of Mr. Warren Moore, manager of the Cheyenne Bottoms Waterfowl Refuge. This transect was 9,740 feet in length. The starting point or station 1 was on the east-central side of pool four and it terminated on the west-central dike. The second line transect began in the northeast corner of pool four. The total length of the second transect line was 1,500 feet.

Belt transects were established on mud flats in pools two and five to measure variations in vegetation due to water fluctuation and soil pH. The belt transect is essentially a line transect having width as well as length. The widths may vary according to the investigator and type of vegetation studied. The belt transects in this study were all three-decimeters wide while the length varied from 100 to 752 feet.

A series of four clip quadrats were utilized. All were located in pool four near the line transects. Clip quadrats are methods of measurement providing information on individual yield of each species. Clippings were taken on July 6, August 6, September 5 and October 6, 1960. Each species was clipped one-inch above the soil surface and placed in paper sacks labeled as to quadrat number, location, and species of grass, forb, or sedge. The contents were air-dried and weighed to determine yield.

The square-foot method as developed by Voigt and Weaver (1951) was employed in pools four and five. The square-foot quadrat is a portable steel or wooden frame enclosing one-square foot. It was used in this study to determine vegetational changes due to water fluctuations.

Soil samples were collected to determine soil texture, moisture and pH. A small "T" shaped geotome was used to collect core samples taken to a depth of 6 inches. These samples were placed in seamless metal cans and weighed before placing in an oven. After drying the soil samples were weighed again to determine soil moisture percentage. Some core samples were oven-dried and later tested by the hydrometer method to determine their textural classification.

Soil temperatures were determined by a dial-type thermometer. Soil samples and soil temperatures were taken along line transects, belt transects, and at various points on the dikes. Three holes twenty-eight inches deep were dug in pools four and five to obtain information on the soil profile. An electrometer was used to determine the pH . One gram of soil was mixed with one thirty-two thousandths milliliters of distilled water to form a paste. This paste was brought into contact with an electrode attached to the pH computer. By adjusting the selective dial the pH of the soil paste was determined.

The water level in each pool was recorded on relief maps. Data was taken at the first of each month from May, 1960 to October, 1960. If appreciable changes were noted in the water level during the month additional recordings were made. In addition surface water was measured in centimeters.

The nomenclature of all plants was taken from Rydberg (1932) and Hitchcock (1950).

DESCRIPTION OF AREA STUDIED

Location

Cheyenne Bottoms is located in central Barton County. It is a large basin roughly circular in shape comprising about 60 square miles. The actual area studied was no more than 18 square miles in size. Cheyenne Bottoms is characterized by a flat, featureless terrain sloping gently toward the east and southeast (Fig. 1)

Cheyenne Bottoms is surrounded on all but the east and southeast sides by low-lying hills composed of shale, limestone, sandstone, and clay. The gentle rise beyond the basin to the east and southeast is due to wind blown deposits. The sandy areas support a vegetation quite different from that found in the basin.

Blood Creek and Deception Creek are the two primary drainage systems entering Cheyenne Bottoms. Blood Creek drains the uplands of northwestern Barton County and enters Cheyenne Bottoms on the west end. Deception Creek and its tributaries are short streams and enter the basin on the northern edge.

Blood Creek intercepts the flat expanses of Cheyenne Bottoms south of Hoisington, Kansas. At a point about 10 miles above Cheyenne Bottoms, Blood Creek flows into a flat valley, varying from three-eights to one mile in width. On the north and south sides of the narrow valley are rolling hills capped by sandstone and limestone. Upstream from this point the water has not cut through the underlying limestone and shale.

Fig. 1. Featureless plain supporting hydrophytic vetetation.

The area studied contained 12,290 acres divided into five pools separated by dikes (Table 1). These dikes also serve for passage of vehicles on the flat upper surfaces. The shoulders of the dikes support a vegetative composition diffrent than that of the pools. Due to wave action all dikes are severely eroded. Most of the erosion occurs during winter and early spring months when the pools are filled with water. The north-and-west facing dike exposures display the greatest degree of erosion. This is due to the prevailing winds and a lack of vegetation during this time of the year.

Table 1. Size of each pool at Cheyenne Bottoms Wildfowl Refuge

POOL	AREAS
POOL NUMBER	ACRES
1	3,300
2	2,940
3	2,140
4	2,620
5	1,290
TOTAL ACRES	12,290

Most of the research was conducted in pool four due to the early removal of water (Fig. II.) Pool one received little attention because of the high water which completely covered it throughout 1960.

Origin of Cheyenne Bottoms

One theory which receives support on the origin of Cheyenne Bottoms was proposed by Hayworth and Miller (Latta, 1950).

Blood Creek and Deception Creek, which are the only two streams of any importance entering Cheyenne Bottoms probably followed the same course as they do now. At one time their channels were cut into the Benton and Dakota sandstones. Since the latter two formations resist erosion quite well the deepening and widening of Blood Creek and Deception Creek were slow. Having cut through these harder layers the softer shales were encountered and as the rate of erosion was increased the two streams began to widen and deepen their valleys. During this period of eroding sandstone and shale, the Arkansas River was slowly working its way northward by wearing away the soft shales along its northern bank until it joined with Blood Creek and Deception Creek.

The Erosion of Benton and Dakota sandstones left behind large deposits of sand (Fig. 2). The sand was blown by the wind forming a ridge across the valley of the two smaller streams resulting in a large basin (Fig. 2). Thus, Cheyenne Bottoms was formed.

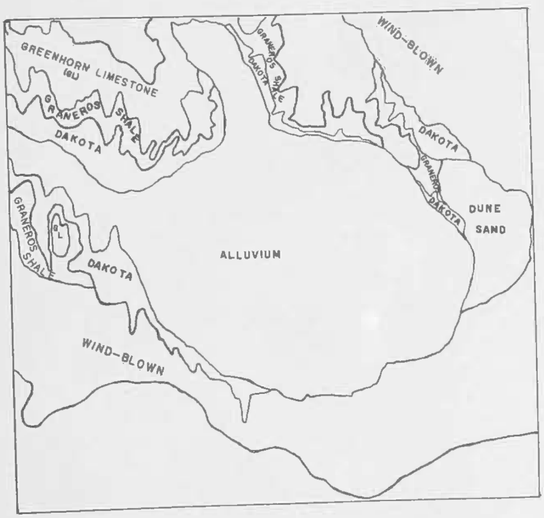

Fig. 2 Geologic formations of the Cheyenne Bottoms Wildfowl Refuge area. Alluvium material covers the large basin. Taken from Latta (1950).

Soils

Alluvium of late Quaternary occurs in Cheyenne Bottoms, Arkansas Valley, Walnut Valley, Dry Walnut Valley, Blood Creek Valley, and other smaller streams of Barton and Stafford Counties (Latta, 1950).

Cheyenne Bottoms is underlain by an unconsolidated stata of clay, silt, sand and gravel of the Dakota formation (Fig. 3). The thickness of the deposits range from less than 20 feet near the margin of the bottoms to more than 100 feet in the old buried channel of Blood Creek. The old channel is approximately in the center of Cheyenne Bottoms and runs from the northwest to the southeast.

Fine-grained sediments, including clay, silt, sand and silt, make up a large part of the fill in Cheyenne Bottoms. Beds of silt range from 2 to 22 feet in thickness. The gravel is composed primarily of sandstone.

Soil Profile Descriptions

Profile descriptions were taken on May 26, 1960, at three locations. Two locations in pool four were selected while the third site was in pool five.

A hole twenty-eight inches deep and eighteen inches on a side was excavated at each site. Water was encountered at the 26 to 28 inch level. On, or about May 5, 1960, the areas chosen for soil profile readings were covered by water. Due to the water cover on pools one, two and three, no soil profile descriptions were obtained. Soil profile descriptions were not taken on the existing dikes because of their eroded condition.

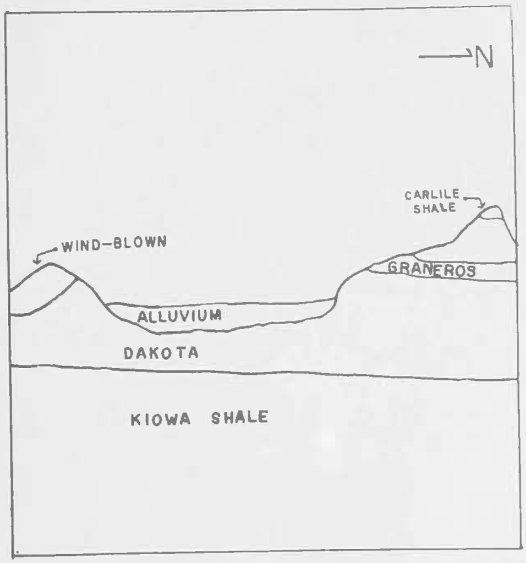

Fig. 3 A cross-sectional view of Cheyenne Bottoms showing the location of the Dakota formation. Taken from Latta (1950)

Site one was in the extreme northeast corner of pool four near the dune sands which characterize the area adjacent to the east portion of the basin.

Plants observed growing in the immediate region of site one were as follows: salt grass (Distichlis stricta) (Torr.), Japanese brome (Bromus japonicus) (Thunb.), sprangle top (Leptochloa uninervia and L. fascicularis) (Link.), narrowleaf groundcherry (Physalia lanceolata) (Michx.), narrowleaf lambsquarter (Chenopodium lanceolatum) (Muhl.) curly dock (Rumex crispus) (L.), spike rush (Eleocharis engelmanni, E. olivacea) (Steud. and Torr.), tall dock (Rumex altissimus) (Wood), broadleaf four-o'clock (Allionia myctaginea) (Michx.), and young seedlings of annual sunflower (Helianthus annuus) (L.) and cocklebur (Xanthium commune) (Britton).

SOIL PROFILE DESCRIPTION OF SITE ONE, POOL FOUR

Surface:
0-3 inches: compact layer of clayey material with little if any structure. Thin layer of fine sand present on surface. Vegetation rhizomatous. Rhizomes present at 3 inch level.

3-7 inches: dense clay with a blocky structure; continuous clay skins present on the surface of the peds; some fine roots present; few fine rock fragments through horizon.

8-24 inches: dense clay with medium to fine blocky structure; clay skins are continuous on surface of peds; fine roots present to 24 inches; rock fragments more numerous than in above horizon; rust brown spots and streaks present indicating impeded profile drainage.

28-- inches: Water encountered.

Site two was near the southwest corner of pool four, on a slight elevation. The dominant vegetation of the area was a spikerush with scattered bunches of dock.

SOIL PROFILE DESCRIPTION OF SITE TWO, POOL FOUR

0-4 inches: compact layer of clayey material. Little if any structure. No sand present on surface. Rhizomes in lesser amounts than at site one.

4-9 inches: dense clay with blocky structure. Clay skins present on the surface of the peds at the 6 to 9 inch level. Very few fine roots present.

9-23 inches: dense clay with a fine blocky structure. Clay skins are present on all peds throughout this level. Rock fragments seen. Rust brown spots and streaks indicating an impeded profile drainage.

23-26 inches: water encountered.

Site three was located at the west-central end of pool five. The dominant vegetation at the site consisted of salt grass, spike-rush, barnyard grass (Echinochloa crusgalli) (L.), and jungle rice (E. colonum) (L.). Subdominants were sprangle top, foxtail barley (Hordeum jubatum) (L.), Japanese brome. Lesser amounts of witch grass (Panicum capillare) (L.), Virginia wild rye (Elymus virginicus) (L.), western wheat grass (Agropyron smithii) (Rydb.), and salt bush (Atriplex hastata) (L.) were also found at site three.

SOIL PROFILE DESCRIPTION OF SITE THREE, POOL FIVE.

Surface:

0-2 inches: loose layer of silt with little conformity. A few fine roots in this layer.

2-5 inches: layer of clayey material having little if any structure. Some fine roots seen.

5-27 inches: dense clay with medium to fine blocky structure. Clay skins present on surface of peds. Rock fragments much more numerous than at site two. Fine roots seen. Profile did not show any definite signs of impeded profile drainage.

27-- inches: similar to 5 to 27 inch description except rock fragments are larger. Water began to seep into hole.

Textural Classification of Soils in Pools

Soils of Cheyenne Bottoms are of an alluvium nature. Clayey material is abundant throughout the basin. The only exception to the clayey material occurs on the eastern shoreline of pool four. In this region the dune sands begin to influence the soil characteristics.

Textural classification of the pools and within the pools themselves vary little. Existing road dikes in some instances had a higher clay content than the pools. Textural analysis were taken in all pools except pool one. The following table lists the per cent sand, silt and clay for pools two, three, four and five.

Table 2. Average percentages of sand, silt, and clay in pool two, three, four and five.

POOL	Per Cent Sand	Per Cent Silt	Per Cent Clay
2	15.3	27.9	56.8
3	17.5	25.3	57.2
4	18.4	34.7	46.9
5	17.3	30.7	52.0

Textural Classification of Dikes

Samples for textural classification on the road dikes were taken four feet from the edge of the road which is located on top of the dikes. The table below lists the per cent of sand, silt, and clay which were found on the dikes. Dike descriptions correspond to the lettering of the dikes on Figure 8 page 22.

Table 3. Average percentage of sand, silt, and clay on the existing road dikes.

DIKE	Per Cent Sand	Per Cent Silt	Per Cent Clay
A-B	15.5	27.0	57.5
B-C	14.9	25.9	59.2
C-E	19.8	21.3	54.0
E-G	20.4	25.6	54.0
B-G	17.0	19.4	63.6

Acidity and Alkalinity of the Pools

The pH factors were all obtained with an electrometer. Soil samples were taken during June, July, August and September to determine soil pH of pools two, three, four and five (Figs. 4, 5, 6 and 7).

All pools had a slight increase in pH which was related to water removal throughout the summer of 1960. A rise in soil pH was due to evaporation of water resulting in an upward migration of salts (Daubenmire,1959). For example, soil pH readings for June, 1960 ranged from 6.1 to 7.4 whereas August readings were as high as 6.7 to 8.0 (Figs. 4 and 6). However, exceptions were noted in pools two and three. Although a shallow layer of water covered a substantial portion of pools two and three an increase in soil pH occurred during August in the southeast corner of pool two and the southwest portion of pool three (Figs. 5 and 6).

A soil pH value of 8.0 was recorded in pool two in August. This was an area characterized by stunted growths of sprangle top, barnyard grass and Japanese millet (Echinochloa spp.),(seeded August 1, 1960) and robust stands of salt grass and small seedlings of salt cedar

Acidity and Alkalinity of the Dikes

The pH values of the dikes were in all instances as great or greater than those found in the pools for a corresponding date (Fig. 8). Only the upper portions of the dikes were sampled. All soil samples were collected in August except for the one sample which was taken in July. Soil pH on the dikes varied from 7.5 to 8.2 (Fig. 8).

White salt deposits on the dikes were noted throughout the summer of 1960. A similar condition was noticeable along the outlet canal dike and on the dike separating pools one and five.

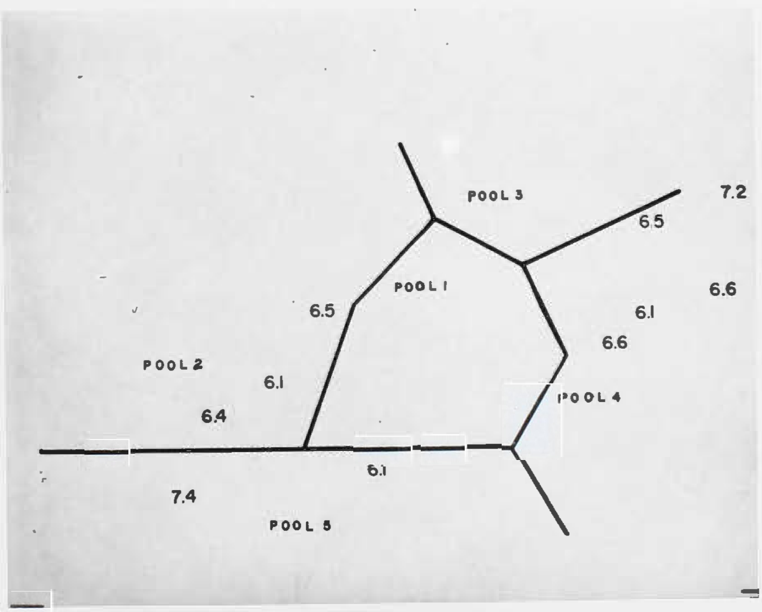

Fig. 4 Soil pH readings in pools at Cheyenne Bottoms during June, 1960. Position of figures represents approximate location of sampling.

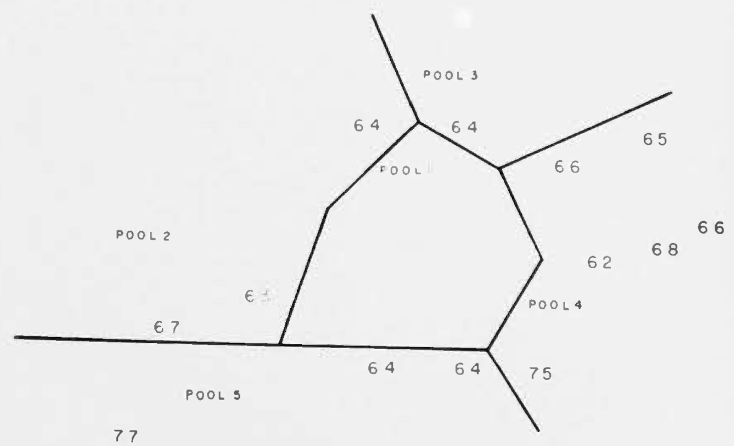

Fig. 5 Soil pH readings in pools at Cheyenne Bottoms during July, 1960. Position of figures represents approximate location of sampling.

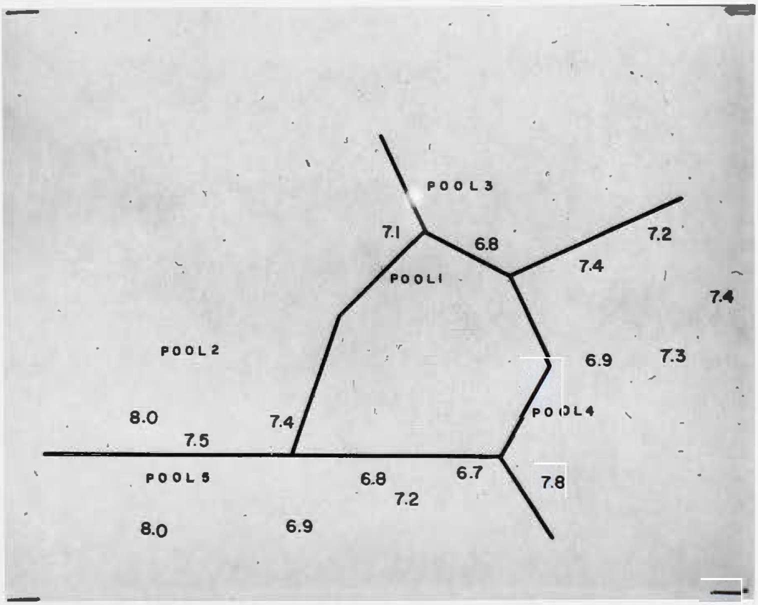

Fig. 6 Soil pH readings in pools at Cheyenne Bottoms during August, 1960. Position of figures represents approximate location of sampling.

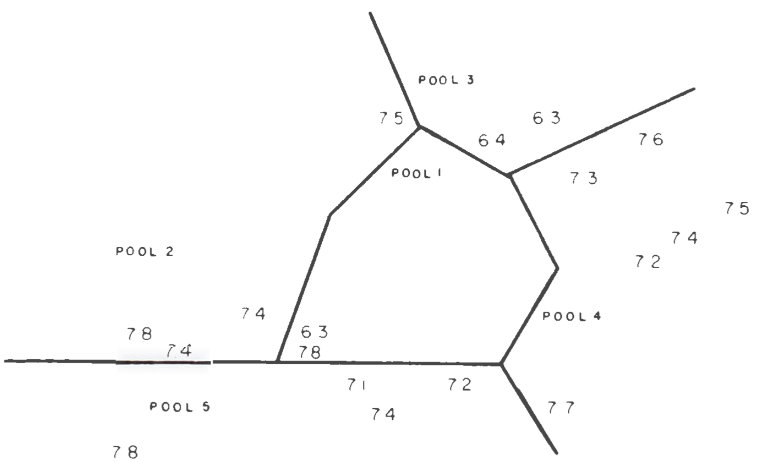

Fig. 7 Soil pH readings in pools at Cheyenne Bottoms during September, 1960. Position of figures represents approximate location of sampling.

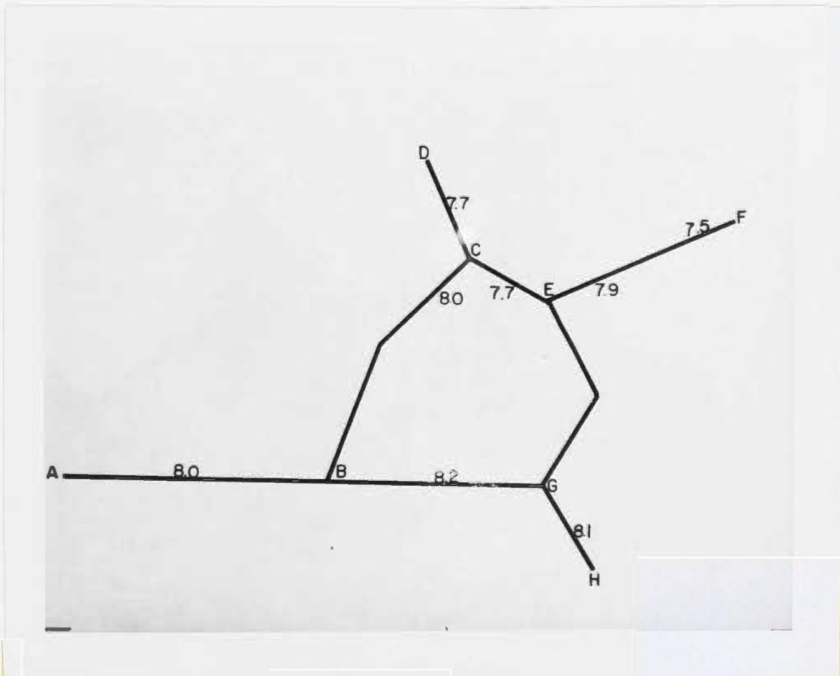

Fig. 8 Soil pH readings on dikes at Cheyenne Bottoms during July and August, 1960. Position of figures represents approximate location of sampling.

VEGETATION DESCRIPTION

Vegetation found in and immediately adjacent to the Cheyenne Bottoms Waterfowl Refuge area is predominately of the type which characterizes a secondary successional development. This is probably because much of the area was under cultivation prior to the time the Kansas Forestry, Fish and Game Commission purchased the land for a waterfowl refuge and public recreational area.

Another factor which exists today and which influences the type of vegetation growing in the pools is alternating flooding and draining.

During periods of drought, water from Walnut Creek, Arkansas River, Blood Creek and Deception Creek watersheds is not plentiful enough to maintain the water at conservation levels in the pools. Hence, plants such as the bulrushes (Scirpus sp.) which grow favorably in abundant water are replaced by vegetation which can withstand semi-arid conditions (Weaver and Himmel, 1930). Drought conditions are accentuated when the texture of the soils is predominately clay. Clayey soils during dry periods usually support vegetation which has a root system capable of penetrating the compact layers. Clayey soils are marked by a higher hygroscopic coefficient which also influences the type of vegetation found growing on them during dry periods.

A dependence of root development of most plants upon aeration can be noted in water-logged soils (Weaver and Himmel, 1930). Hence, fine textured clayey soils when subjected to excessive amounts of moisture are detrimental to plant growth, due to the water retaining capacity of clay soils.

Road Dike Vegetation

Various stages of secondary succession were found on the slopes of the dikes. Pure stands of firewood (Kochia scoparia) (L), ten to twenty feet wide and up to sixty feet in length were common. Many adjacent areas had foxtail barley, Japanese brome, and salt grass. An example of areas which supported various species at different levels on the dikes in relation to soil moisture, soil pH, and soil texture are shown diagramtically in Fig. 9.

During late spring (vernal aspect) the dikes were characterized by foxtail barley, Japanese brome and squirrel tail (Sitanion hystrix) (Nutt.). Species which appeared later during the estival and autumnal aspects as the dominant vegetation in various dike positions were as follows:

Common name	Scientific name
Western wheatgrass	Agropyron smithii (Rybd.)
Daisy fleabane	Erigeron racemosus (Nutt.)
Yellow foxtail	Setaria lutescens (Weigel)
Green foxtail	Setaria viridis (L.)
Salt grass	Distichlis stricta (Torr.)
Torrey's pigweed	Amaranthus torreyi (Gray)
Salt bush	Atriplex hastata (L.)
Western ragweed	Ambrosia psilostachya (Gray.)
Many-flowered aster	Aster multiflorous (L.)
Mat spurge	Chamaesyce polygonifolia (L.)
Fireweed	Kochia scoparia (L.)
Annual sunflower	Helianthus annuus (L.)

Common name	Scientific name
Snow-on-the mountain	Euphorbia marginata (Pursh.)
Witch grass	Panicum capillare (L.)
Crab grass	Digitaria sanguinalis (L.)
Barnyard grass	Echinochloa crusgalli (L.)
Sprangle top	Leptochloa uniervia - L. fascicularis (Lam. & Presl.)

Other grasses and forbs which were intermixed in lesser amounts with the above plants were as follows:

Common name	Scientific name
Tall dock	Rumex altissimus (Wood)
Curly dock	Rumex crispus (L.)
Marsh cress	Rorripa sinuata (Nutt.)
Narrowlead four-o'clock	Physalis lanceolata (Michx.)
Texas crab grass	Schedonnardus paniculatus (Nutt.)
Silver beard bluestem	Andropogon saccharoides (Swartz.)
Buffalo bur	Solanum rostratum (Tourn.)
Narrowleaf lambsquarter	Chenopodium lanceolatum (Muhl.)
Puncture vine	Tribulus terrestris (L.)
Wild lettuce	Lactuca ludoviciana (Nutt.)
Knotweed	Polygonum aviculare (L.)
Mare's tail	Leptilon canadense (L.)
Yellow sweet clover	Melilotus officinalis (L.)
White sweet clover	Melilotus alba (Desv.)
Salsify	Tragopogon pratensis (L.)
Cockle bur	Xanthium commune (Britton)

Common name	Scientific name
Switch grass	Panicum virgatum (L.)
Side-oats grama	Bouteloua curtipendula (Michx.)
Virginia wildrye	Elymus virginicus (L.)
Canada wildrye	Elymus canadensis (L.)
Stink grass	Eragrostis cilianensis (All.)
Little barley	Hordeum pusillum (Nutt.)
Johnson grass	Sorghum halepense (L.)
Poverty dropseed	Sporobolus neglectus (Nash.)
Windmill grass	Chloris verticillata (Nutt.)
Reed canary grass	Phalaris aurundinacea (L.)
Prairie cord grass	Spartina pectinata (Link.)
Fall witch grass	Panicum dichotomiflorum (Michx.)
Illinois bundle flower	Desmanthus illinoensis (Michx.)
Dakota verbena	Verbena bipinnatifida (Nutt.)
Missouri goldenrod	Solidago glaberrima (Martens.)
Texas sandbur	Cenchrus pauciflorus (Benth.)
Common yellow oxalis	Oxalis stricta (L.)

There is considerable variation in the vegetation found on the upper and lower slopes of the dikes (Fig. 10.).

Near the lower portions of the slopes tall dock, curly dock, prairie cord grass, reed canary grass, common bulrush (Scirpus validus) (Vahl), river bulrush (Scirpus fluviatilis) (Torr.), sprangle top, Torrey's pigweed, barnyard grass, salt cedar, smart weed (Polygonum coccinea), (Muhl.) ammannia (Ammannia coccinea and A. auriculata), (Rottb. & Willd.), spike rush, and an occasional cattail (Typha latifolia), (L.), were found growing in or near the water.

Symbol	Common name	Scientific name
Ksc	Fireweed	Kochia scoparia
Hju	Fixtail barley	Hordeum jubatum
Bja	Japanese brome	Bromus japonicus
Shy	Squirrel tail	Sitanion hystrix
Era	Daisy fleabane	Erigeron racemosus
Pca	Witch grass	Panicum capillare
Asm	Western wheatgrass	Agropyron smithii
Lca	Mare's tail	Leptilon canadense
Aha	Salt bush	Atriplex hastata
Dst	Salt grass	Distichlis stricta
Han	Common sunflower	Helianthus annus
Sva	Soft stem bulrush	Scripus validus
Sac	Hard stem bulrush	Scripus acutus
Pla	Annual smart weed	Polygorum lapthafolia
Pco	Smart weed	Polygonum coccinea
Tla	Cattail	Typha latifolia
Rcr	Curly dock	Rumex crispus
Lfa	Sprangle top	Leptochloa fascicularis
Ecr	Barnyard grass	Echinochloa crusgalli

Fig. 9. Various species at different levels on the dikes in relation to soil moisture, soil pH and soil texture. Each symbol indicates the species of plant found within the segregated area. The first symbol denoted the dominant vegetation, while the other symbols designate subdominant species. Below the plant symbols are soil pH, soil moisture, and soil textural classification. These soil measurements were made on August 10, 1960. One inch on graph equals 15 feet on ground.

Each symbol indicates the species of plant found within the marked off area. The first symbol denotes the dominant vegetation, while the other symbols designate subdominant species. Below the plant symbols are soil pH, soil moisture, and soil textural classification. These soil measurements were made on August 10, 1960. One inch on graph equals 15 feet on ground.

Ksc Hju Bja Shy Era Pca Asm Lca	Aha	Dst	Han	Sva Sac Pla Pco Tla Rcr	Lfa Ecr
pH 7.9 Soil Moisture 14.22 Per Cent Sand 14.40 Per Cent Silt 27.20 Per Cent Clay 58.40	pH 8.0			Soil Moisture 30.09	pH 6.5

Symbol	Common name	Scientific name
Sac	Hard stem bulrush	Scripus acutus
Tla	Cattail	Typha latifolia
Rcr	Curly dock	Rumex crispus
Ecr	Barnyard grass	Echinochloa crusgalli
Llu	Wild lettuce	Lactuca ludoviciana
Hju	Foxtail barley	Hordeum jubatum
Asm	Western wheat grass	Agropyron smithii
Ksc	Fireweed	Kochia scoparia
Mal	White sweet clover	Melilotus alba
Spe	Prairie cord grass	Spartina pectinata
Lfa	Sprangle top	Leptochloa fascicularis
Een	Spike rush	Eleocharis engelmanni

Fig. 10 Cross sectional view of dikes showing distribution of species

The upper half of the dikes were usually found supporting yellow sweet clover, white sweet clover, salt grass, western wheatgrass, witch grass, Texas crab grass, poverty grass, foxtail barley, little barley, crab grass, yellow and green foxtail, Japanese brome, windmill grass, Virginia and Canada wildrye, wild lettuce, mat spurge, salt busy, daisy fleabane, fireweed, western ragweed, and narrowleaf lambsquarter.

The dominant vegetation found on the dikes was western wheat grass (Table 4). Japanese brome was the primary subdominant species. Basal cover on the dikes was similar to pool four.

Table 4. Average percent basal cover and percentage composition of vegetation on dikes at Cheyenne Bottoms. Measurements taken July, 1960

Basal cover and species	Per cent cover and species composition
Basal cover	16.07
Western wheatgrass	42.80
Japanese brome	27.58
Salt grass	8.32
Reed canary grass	6.40
White sweet clover	2.95
Sprangle top	1.97
Spike rush	1.97
Yellow sweet clover	1.97
Wild lettuce	1.47
Western ragweed	0.98
Side-oats grama	0.98
Squirrel tail	0.98
Salt bush	0.49
Switch grass	0.49
Carex sp.	0.49
Prairie cord grass	0.49

PLANT AND WATER RELATIONS IN THE POOLS

Natural drainage at Cheyenne Bottoms occurs from Blood and Deception Creeks. These two creeks enter pool two in the west edge and north central portions, respectively, and soon blend into the general flat characteristics of the pool. All perimeter pools receive runoff from the higher topography which surrounds Cheyenne Bottoms on all sides except the east and southeast. The principal source of water is derived from an inlet canal which diverts the Walnut Creek and Arkansas River. During the spring and summer, water is diverted from all sources and stored in pool one. About September 15 impounded water is allowed to flow into the perimeter pools two, three, four and five. The water level is regulated to provide ideal conditions for migratory waterfowl.

Water impounded in the pools, as recommended by the Kansas Forestry, Fish and Game Commission, is maintained at the 1,794.5 level in pools two, three, four and five. In pool one the desirable level is 1,798.0 feet. All water elevations are referred to as normal or conservation levels.

The conservation level is continued throughout the winter and spring until May 15 or June 1, depending on snow and rainfall. Maintaining water at the conservative level is intended to discourage growth of undesirable weedy species during the spring months (Eggen and Coleman, 1958).

Water removal from the perimeter pools is accomplished through a drainage canal which leaves Cheyenne Bottoms in the southeast corner at the lowest point. Drainage is continued in pools two, three, four and five until the remaining water is confined to the ditches running parallel to the dikes and in occasional small depressions.

Control of water in 1960 was difficult because of a number of factors. Therefore, the water situation in the pools varied considerably from normal.

Pool one which acts as a reservoir was continually covered by water. Water was completely removed in pool four by July 20th except for in a few depressions and in the borrow ditches (Fig. 11). The surface covering of water was generally removed in pool five by September 5, 1960. The borrow ditches and two small areas in the northeast corner and north central portion of pool five were the only places having a covering of water. However, by September 15 water was again found occupying a substantial portion of pool five.

Large areas in pools two and three were influenced by surface water throughout the study period.

As part of the management program at Cheyenne Bottoms water was again released after September 5th into the surrounding pools from pool one. Therefore, from September 15, 1960 to May 15, 1961, water again covered the flat surfaces of pools two and three and portions of pools four and five.

An attempt is made under normal conditions to maintain a drained condition throughout the summer to provide environmental influences favorable for growth of food plants.

WATER LEVEL MAP

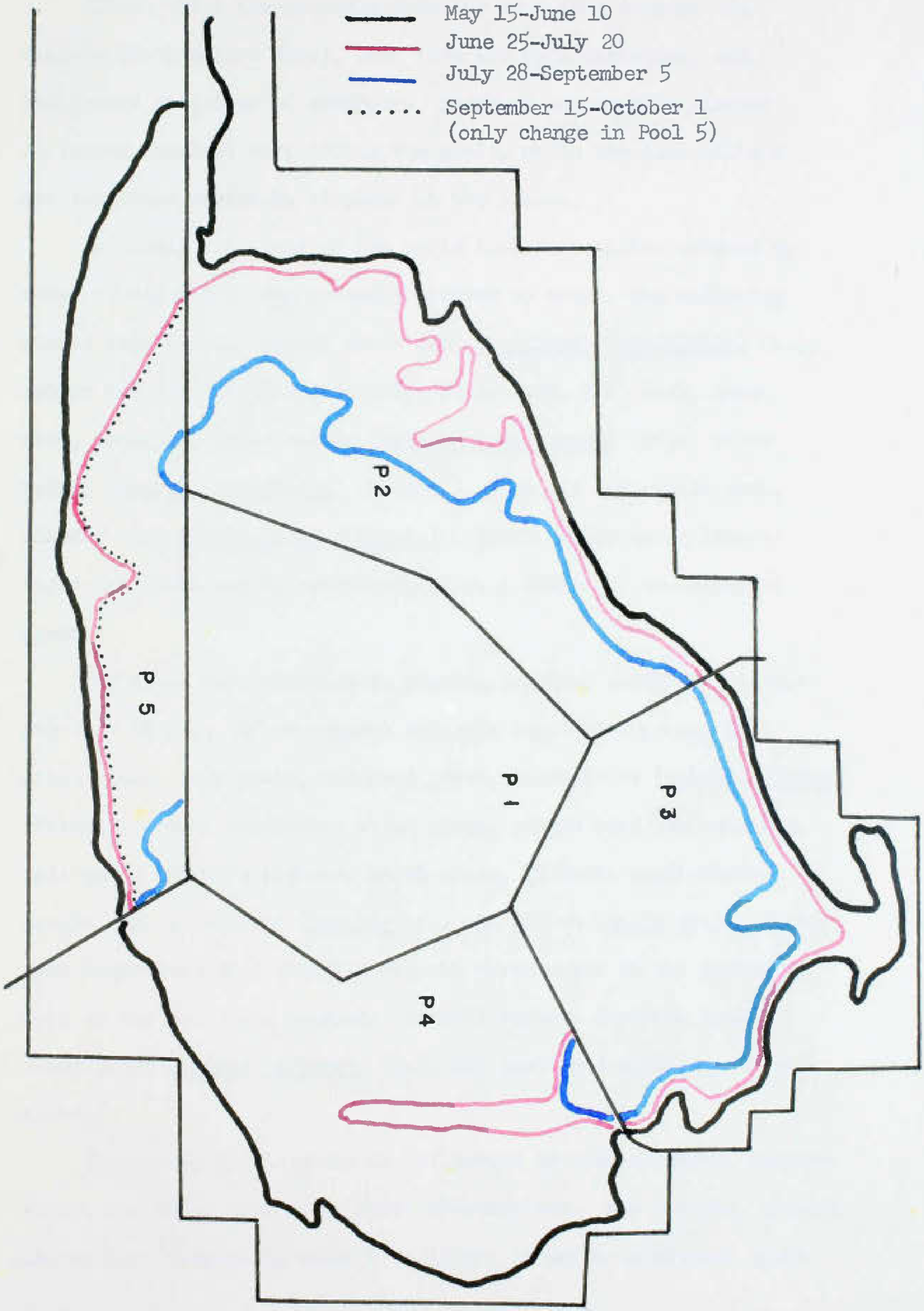

Fig. 11 Water levels at various times of season. Cheyenne Bottoms, 1960.

Plants which are commonly used for duck food include the millets (Echinochloa spp.), both tame and wild varieties, and cultivated varieties of sorghums. Sorghums are usually planted on leased farmland surrounding the pools, while the tame millets are sometimes seeded by airplane in the pools.

In nearly all areas of the pools that were either covered by water or which had been recently covered by water, the following plants were found: annual smart weed (Polygonum lapthafolia) (L.), common and river bulrush, cattail, curly dock, tall dock, smart weed, ammannia, mud-plantain (Heteranthera limosa) (Sw.), water hyssop (Bacopa rotundfolia) (Wettst.), sprangle top, spike rush, bladder wort (Utricularia vulgaris) (Gray), arrow heads (Sagittaria latifolia and S. arifolia)(Willd. & Johnson), and barnyard grass.

Dry areas were elevated to provide physical features suitable for duck blinds. Areas support sprangle top, witch grass, fall witch grass, salt grass, barnyard grass, loosestrife (Lythrum alatum) (Pursh.), annual sunflower, stink grass, narrow leaf lambsquarter, salt bush, Torrey's pigweed, marsh cress, Illinois bundleflower, cockle bur, cottonwood (Populus sp.) and Willow (Salix sp.). These same areas supported sprangle top and marsh cress in the spring as well as the following grasses: foxtail barley, Japanese brome, cheat grass (Bromus tectorum) (L.), and scattered seedlings of salt grass.

Vegetation in the pools is influenced by soil moisture, temperature, and pH as well as by water fluctuations. For example, shallow depressions covered by water 2 to 15 cm. in depth maintained spike rush in addition to water hyssop, ammannia, and mud-plantain. However, if the water cover was less than 2 cm., ammannia and water hyssop withered and died. Water hyssop was most abundant in water 2 to 8 cm. deep while ammannia and mud-plantain competed successfully with the spike rush in water 8 to 15 cm. deep.

Depressions having a continuous cover of water 18 to 30 cm. in depth were often dominated by common and river bulrush. Lesser amounts of cattail, smart weed, ammannia, mud-plantain, and spike rush occupied fringes of river bulrush communities.

On April 25, 1960, spike rush was beginning to appear above the water. This was exceptionally noticeable where the water was not deeper than 45 cm. Pool four supported a thicker stand of spike rush than did pools three, two, and five in that order.

Spike rush decreased in relation to water removal in each of the pools studied. As spike rush decreased sprangle top, barnyard grass, and salt grass increased. An increase in soil moisture from 2 to 9 per cent resulted in a decrease of sprangle top. In less than two weeks 50 to 90 plants per square foot of sprangle top died due to the rise in soil water content.

Pools one, two, three, four and the north central and east portions of pool five displayed vegetation which could be classified as either semi-aquatics or aquatics. However, the extreme fringes of pools, two, three and the western and southern parts of pool five were dominated by plants capable of withstanding semi-arid to arid conditions.

Pool one, which functions as a reservoir, was constantly under the influence of a water cover. The depth of water varied from two to five feet. Vegetation in pool one was primarily scattered communities of bulrushes. Along edges of the pool bladderwort was found growing in thick bulrush communities.

Pool two, which was influenced by a shallow water cover during approximately two-thirds of the growing season, was dominated by spike rush (Table 5).

Table 5. Per cent basal cover and percentage composition of pool two. Measurements taken August, 1960.

Basal cover and species	Per cent cover and species composition
Basal cover	6.71
Spike rush	37.02
Sprangle top	33.61
Salt grass	18.72
Torrey's pigweed	2.12
River bulrush	2.12
Ammannia	1.70
Barnyard grass	1.70
Squirrel tail	.85
Mat spurge	.85
Curly dock	.85
Prairie cord grass	.42

From June 1 to August 10, 1960 soil moisture in pool two dropped from 31 to 21 per cent. In one month, August 10 to September 7, a 10 per cent loss in soil moisture resulted in an increase of sprangle top and a decrease of spike rush (Fig. 12).

Cultivated varieties of Japanese millet were seeded on August 1, 1960 in pools two, three, four and five at a rate of 20 lbs. per acre. The increase in the abundance and growth of Japanese millet was slight during August and early September (Fig. 12).

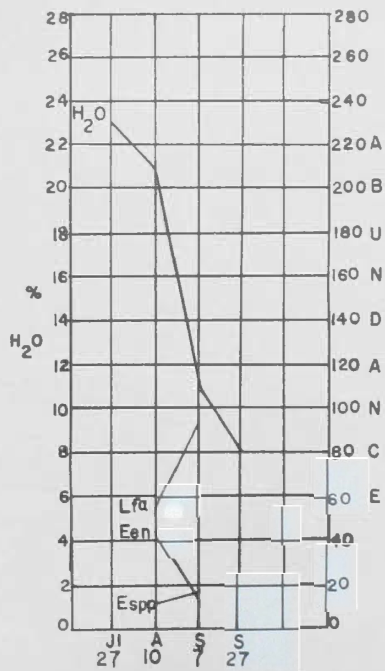

Fig. 12. Abundance of grass seedlings in relation to percent of water in the soil. Sprangle top is represented by Lfa, spike rush by Een, and Japanese millet by E. spp. Sprangle top increased and spike rush decreased as a result of a 10 per cent decrease in soil moisture.

Water remained on the greater portion of pool three until late August and early September. Spike rush made up over 90 per cent of the vegetation (Table 6). River bulrush, salt grass, smartweed and ammannia made up the remaining 10 per cent.

Table 6. Per cent basal cover and percentage composition of pool three. Measurements taken September, 1960.

Basal cover and Species	Per cent cover and species composition
Basal cover	10.25
Spike rush	91.05
River bulrush	4.06
Salt grass	1.62
Smart weed	1.62
Ammannia	1.62

The initial removal of water from pool four in May and June permitted an early study of the vegetation. Ninety-five per cent of the water had been removed by July 5, 1960.

Spike rush made up 89 per cent of the total vegetation in pool four while sprangle top was the major subdominant species (Table 7). Other less important species were: Barnyard grass, ammannia, smart weed, salt grass, water hyssop, mud-plantain, cattail, mat spurge, loosestrife, yellow wood sorrel, river bulrush and curly and tall dock.

The areas in pool four were selected to study the vegetation in relation to water fluctations. One was located in the northeast portion of pool four. Another area approximately 10 feet in width and 9,740 feet in length and began on the east and terminated on the west shorelines of pool four.

Table 7. Per cent basal cover and percentage composition of vegetation in pool four. Measurements taken July, 1960.

Basal cover and Species	Per cent cover and species composition
Basal cover	17.21
Spike rush	89.22
Sprangle top	5.86
Water hyssop	1.57
Smart weed	1.57
Barnyard grass	1.27
Ammannia	.60
Salt grass	.42
Cattail	.39
Mud-plantain	.30
Mat spurge	.24
Yellow wood sorrel	.24
River bulrush	.06
Loosestrife	.06
Curly and tall dock	.06

Appearance of sprangle top on elevated sites in pool four was due to removal of water during May. For example, an area totally removed of water on May 27, 1960 was found supporting a large number of sprangle top seedlings by June 1st. There were, however, some depressions in pool four dominated by spike rush and/or river bulrush throughout the 1960 growing season. The sites were devoid of sprangle top, barnyard grass, salt grass and mat spurge.

Areas where water was totally removed were unable to maintain a stand of spike rush. This resulted in appearance of sprangle top and meager amounts of barnyard grass.

Spike rush on June 1st numbered over 280 individual plants per square foot along one transect but on August 10th it was nearly absent (Fig. 13). Soil moisture for the period varied from 20 to 24 per cent during June to 5 per cent on August 10th. An increase in soil moisture in July along another transect in an increase in the density of spike rush--showing the relationship of this species to soil moisture (Fig. 14).

Effects of soil moisture on sprangle top were quite different from effects on spike rush. An increase in soil moisture resulted in a decrease of sprangle top along both transects, whereas a reduction in soil moisture caused a substantial gain of sprangle top.

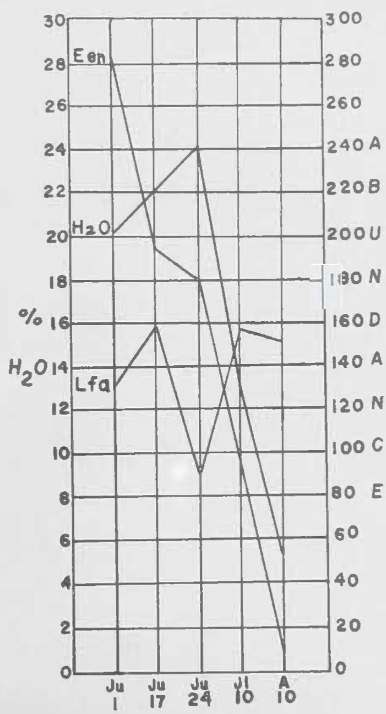

Fig. 13. Abundance of grass seedlings in relation to water in soil. Spike rush is represented by Een and sprangle top by Lfa. A decrease in soil moisture resulted in a corresponding decrease in spike rush.

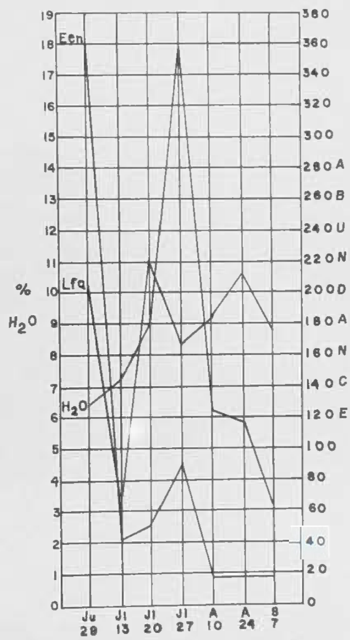

Fig. 14. Abundance of grass seedlings in relation to water in soil. Spike rush is represented by Een and sprangle top by Lfa. An increase of soil moisture during July resulted in an increase of spike rush and a decrease of sprangle top.

Point transects recorded during August in pool five revealed that 78 per cent of the vegetation was composed of salt grass, spike rush and barnyard grass. Sprangle top made up 15 per cent of the vegetation at the time. (Table 8).

Table 8. Per cent of basal cover and percentage composition of vegetation in pool five. Measurements taken August, 1960.

Basal cover and Species	Per cent cover and species composition
Basal cover	5.70
Salt grass	28.12
Spike rush	25.62
Barnyard grass	25.62
Sprangle top	15.00
Torrey's pigweed	3.12
Ammannia	1.25
Salt bush	.62
Witch grass	.62

Lesser amounts of torrey's pigweed, ammannia, salt bush, and witch grass were found in pool five. Earlier in the season (May and June)western and southern portions of pool five supported foxtail barley, western wheat grass, Japanese brome, salt grass, Canada wild rye, Virginia wild rye, squirrel tail, mat spurge, Texas crab grass, salt bush, curly dock, marsh cress, prostrate pigweed (Amaranthus blitoides) (S. Wats.), western ragweed, giant ragweed (Ambrosia trifida (L), little barley and wild lettuce.

Additional studies using belt transects were made during August to determine the relationship of soil moisture and plant survival on mud flats (Fig. 15).

Soil moisture was 24 per cent in July, 1960, but in one month it decreased to 11 per cent. Five weeks later the soil moisture was only nine per cent. During the period of decreased soil moisture sprangle top, Japanese millet and spike rush increased.

Spike rush increased from 115 to 135 plants per unit in five weeks. Each unit area was 3 decimeters wide and 12 inches in length. In a corresponding period of time sprangle top and Japanese millet increased from 50 to 110 and from 18 to 162 plants, respectively (Fig. 15).

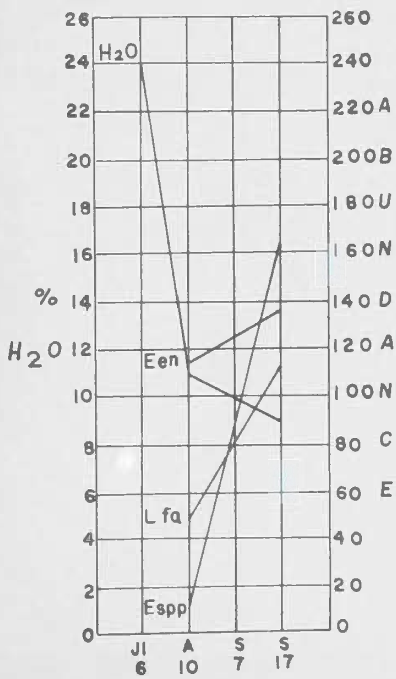

Fig. 15. Abundance of grass seedlings in relation to water in soil. Spike rush is represented by Een, sprangle top by Lfa, and Japanese millet by E. spp. A decrease in soil moisture resulted in an increase of spike rush, sprangle top and Japanese millet.

Japanese millet in pool five began flowering in late August and early September. The majority of plants were not over 6 to 8 inches in height at the time of anthesis. From September 7th to October 1, 1960 Japanese millet produced a few seeds on the lower portions of the head. However, seed production was light.

Sprangle top failed to head if it germinated as late as the last two weeks in August. However, plants which had germinated and developed during July and early August flowered and produced a good seed crop. Several locations which supported sprangle top were found producing enough seed to cover the ground.

Throughout the entire study period ammannia and water hyssop decreased and sometimes disappeared altogether in relation to a decrease in soil moisture. Continued growth was assured of the bulrushes and cattails where the water remained in shallow depressions.

CLIP QUADRAT DATA

The clip quadrat method was used to ascertain yield of various species in pool four. Yields were substantially greater in June compared to yields of July through September, inclusive (Table 9).

Total yield in June was four times greater than the July forage production. The decrease in forage production corresponded with the removal of water in pool four. Spike rush, which produced 2,785.7 pounds per acre in June, failed to yield in September. A decrease in production in pool four corresponded to the reduction in number of individual plants of spike rush found in the belt transect.

The only species which produced any forage in September was barnyard grass.

Table 9. Monthly and seasonal yields of individual species in pool four. Forage production given in pounds per acre.

Species	June	July	August	September	Total Seasonal yield.
Spike rush	2,785	768.1	61.5	------	3,615.3
Sprangle top	544.7	43.7	98.8	------	687.2
Barnyard grass	-----	-----	36.5	4.5	41.0
Illinois bundle flower	4.5	-----	-----	-------	4.5
Carex spp.	0.9	-----	-----	--------	0.9
Mat spurge	-----	8.1	-----	-------	8.1
Loose strife	---	-----	3.6	-------	3.6
Total	3,335.8	819.9	200.4	4.5	4,360.6

Increased yield of sprangle top during August, which is in contrast to the decrease in forage production for July, was due to emerging grass seedlings during the second and third weeks of August. Renewal of sprangle top germination in August followed the decrease in spike rush production in July.

Total seasonal production in pool four was 4,360.6 pounds per acre. The yield is similar to the production of lowland areas supporting native grassland vegetation near Hays, Kansas (Unpublished data, Botany Department, Fort Hays Kansas State College.

SUMMARY

The study began in April, 1960, to determine environmental influences on growth and survival of hydrophytic, mesopytic and xerophytic vegetation within the Cheyenne Bottoms waterfowl Refuge area.

Cheyenne Bottoms is a basin roughly circular in shape and comprising a 60 square-mile area. The area, acquired by the Kansas State Fish and Game Commission, is divided into five pools. Dikes provide the inner boundaries of pools two, three, four and five and the perimeter of pool one. Cheyenne Bottoms is surrounded on all but the east and southeast sides by low-lying hills composed of shale, limestone, sandstone and clay. The sandy areas are found primarily to the east of the basin.

The objective of the Cheyenne Bottoms Refuge is to utilize the area for feeding and resting of migratory, as well as non-migratory waterfowl. Water manipulation is an important phase in the attainment of this objective.

Two natural drainage systems, Blood Creek and Deception Creek, and the inlet canal are the principal sources of water supplying Cheyenne Bottoms.

Methods used to ascertain the plant cover and composition and the relation of plants to water were the point quadrat, line and belt transect, and the square-foot and clip quadrat. Soil texture was determined by the hydrometer method. Soil samples were taken periodically to determine soil moisture and pH.

Profile descriptions were obtained May 26, 1960, to determine root penetration and soil structure. Two sites were chosen in pool

four while a third was selected in pool five. In addition to the recording of soil profiles, the vegetation of each site was also listed.

Textural analysis revealed that the soil's surface layers were high in clay content. Confirmation of this was shown by earlier geological studies (Latta, 1950). Cheyenne Bottoms is underlaid by an unconsolidated strata of clay, silt, sand and gravel. The thickness of these deposite range from less than 20 feet near the margin to more than 100 feet in other portions of the basin.

Two theories were proposed in the late 19th century on the origin of the bottoms. One such theory which receives support was proposed by Hayworth and Miller (Latta, 1950).

Vegetation in and immediately adjacent to the bottoms characterizes a secondary successional development. Plant species found in the basin and those found on the surrounding slopes are quite different. The uplands are characterized by those species which grow in mesic and xeric conditions, while the vegetation in the basin varies from hydrophytes within the pools to mesophytes and halophytes on the dikes.

Spike rush was the dominant vegetation in pools two, three and four. Pool five was dominated by salt grass, with spike rush and barnyard grass as principal subdominants.

A correlation was noted between the removal of surface water in the pools and a decrease in hydrophytic vegetation. For example, decreased soil moisture resulted in increased sprangle top and decreased spike rush. However, when the soil moisture decreased from 6 to 3 percent sprangle top also became less abundant. Japanese millet, seeded on August 1, 1960, made a substantial gain in abundance as soil moisture decreased following water removal.

Hydrophytes such as ammannia and water hyssop decreased and in most cases disappeared when the soil moisture decreased. Bulrush and cattail survival was assured where the water remained on the surface. The growth of bulrush and cattail was prevalent in the borrow ditches and shallow depressions within the pools.

The yield of various species in pool four was determined by quadrats. Spike rush had the largest yield during June and July but failed to produce forage in September. Total seasonal production in pool four was 4,360.6 pounds per acre. The total yield was similar to the production of lowland areas supporting native grassland vegetation near Hays, Kansas.

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